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UNDERSTANDING CROSS-COUNTRY DIFFERENCES IN HEALTH STATUS  
AND EXPENDITURES

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Understanding Cross-country Differences in Health Status and Expenditures  
Raquel Fonseca, François Langot, Pierre-Carl Michaud, and Thepthida Sopraseuth  
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**ABSTRACT**

Using a general equilibrium heterogeneous agent model featuring health production, we quantify the relative contribution of price distortions in the health market, TFP and other health risks in explaining cross-country differences in health expenditure (as a share of GDP) and health status. Estimated parameters reveal a substantial price wedge that explains at most 20% of the difference in health spending (as a share of GDP) and 30% of the difference in health status between Europe and the U.S. We estimate a one percentage point negative impact on the life-time cost-of-living of Americans from higher prices due to inefficiencies.

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# 1 Introduction

Large differences in health expenditures are observed across countries. In 2018, the U.S. spent 17% of its GDP on health while Germany spent 11.2% and Italy 8.8% (Health Statistics, OECD 2018).<sup>1</sup> This increasing share of resources devoted to health care is thus one of the largest fiscal challenges facing many OECD countries, and in particular, the United States. One could argue that these differences in health expenditures are the result of differences in wealth and that health is a luxury good: as Americans are richer, they devote a larger share of their wealth to healthcare services. Yet, the aggregate level of health expenditures does not appear to be strongly associated with health outcomes despite compelling evidence that healthcare services improve health. Americans have been repeatedly found to be in worse health than Europeans (Banks et al., 2006) and experience higher incidence rates for various diseases (Solé-Auró et al., 2015). In this paper, we will argue that the cross-country relationship between health expenditures and health status does not identify the marginal return of health services given that prices and quantities of healthcare services vary substantially across countries. Hence, an analysis of understanding why health care spending and health is different across countries needs to account for these differences.

There is compelling evidence of substantial cross-country variation in **prices** for the same services, a **health services wedge**.<sup>2</sup> For example, there is evidence showing that the cost of medical interventions, the price of drugs and physician compensation are significantly larger in the U.S. than European countries (Anderson et al., 2003, Danzon, 2018, Laugesen and Glied, 2011). Cutler and Ly (2011) argue that much of these differences in costs come from the administrative burden of managing a complex reimbursement system while the relationship between providers and payers (insurers) may lead to important wedges due to asymmetric information. At a macro level, Horenstein and Santos (2018) show that the large part of the U.S. gaps of health expenditures as a share of GDP may be driven by the markup increases in the U.S. health care sector. Hence, higher prices due to inefficiencies have the potential of leading to a higher share of income devoted to health, without improving health outcomes.

The **quantity** of health services may also vary across countries. First, due to higher prices

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<sup>1</sup><https://www.oecd.org/health/health-statistics.htm>

<sup>2</sup>The idea to use structural model in order to identify wedges to the efficient allocation has already been used by e.g. Ohanian et al. (2008) who explain cross-country differences in long-term changes in hours worked.

resulting from the health service wedge, even if evidence on the price elasticity of health services suggest a relatively inelastic demand curve (see [Manning et al. \(1987\)](#)). Second, differences in total factor productivity (TFP), an **efficiency wedge**<sup>3</sup>, may explain differences in quantity of health services. The earlier literature on differences in health expenditures has identified income as a key source of differences. Nevertheless, [Gerdtham and Jonsson \(2000\)](#) conclude that the income elasticity of health expenditures is close to one which would suggest, as [Newhouse \(1992\)](#) points out, that income differences cannot explain large variation of the income share of health expenditures. However, [Hall and Jones \(2007\)](#) estimate life-cycle models yielding much higher income elasticities, which partially explains the rise in health expenditures in the U.S. These authors suggest that income elasticity may have been underestimated in previous studies.

As far as we know, there is no general equilibrium model recognizing the endogeneity of health expenditures, health and economic resources that allows to quantify heterogeneous wedges (health services and efficiency) across countries. Indeed, a vast majority of the literature has dealt with the impact of financial incentives on health expenditures or the role of rising income on these expenditures, while the impact of inefficiencies induced by health providers' behavior has received less attention. In order to separately identify health services and efficiency wedges, we build on the framework developed by [Aiyagari \(1994\)](#), augmented with health production as in [Grossman \(1972\)](#). This heterogeneous framework accounts for the well-known within country relationship between income/wealth and health ([Avendano et al., 2009](#), [Smith, 1999](#)). We estimate structural parameters and the two wedges (the health services and efficiency wedges) using a Method of Simulated Moments (MSM), thereby exploiting cross-country disparity in economic resources, health expenditures and health outcomes as well as within country variation (the income-health gradient). Our estimation is performed on 8 countries (the U.S., Sweden, Denmark, the Netherlands, Germany, France, Italy, and Spain). Within this framework, we estimate welfare costs of these wedges using a new measure which can be interpreted as a life-time cost of living index which accounts for the immediate and long-run benefits of investing in health as well as general equilibrium effects.

We find that the U.S. are characterized by the highest health service wedge (ie. the highest price of health services), while its efficiency wedge is one of the lowest (ie. the highest TFP). Our

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<sup>3</sup>[Chari et al. \(2007\)](#) build a macroeconomic model to show that this *efficiency wedge* can be generated by frictions that cause factor inputs to be used inefficiently. This inefficient factor utilization maps into efficiency wedges and thus a lower TFP.

estimation shows that the U.S. price of health services is 15% larger than the average price in European countries. In addition, we find that efficiency wedge cannot account for cross-country differences in health expenditures and health. Using counterfactuals, we show that, when health price distortions in the U.S. have the same order of magnitude as in Europe, the gap in health expenditures would be reduced by 20% while the gap in terms of health status would be reduced by 30%. Differences in terms of health dynamics, which could be the result of differences in underlying risk factors (obesity, smoking, etc) account for a large share of the difference in health spending and health outcomes across countries. Other differences, such as co-insurance rate or the income risks, can not explained the cross-country differences in health status and expenditures. Overall, given that health accounts for less than 15% of resources and Americans substitute away from health due to higher prices which leads to both partial and general equilibrium effects, we find that the extra-cost of living that Americans bear is equivalent to one percentage point in life-time expenditures. As for health inequalities, we show that health service wedge *i*) increases the income-health gradient by 30% and *ii*) makes high-income Americans bear the largest additional cost-of-living.

The paper is structured as follows. In section 2, we document substantial differences in health services prices across countries and discuss other sources of variation that can explain differences in health expenditures and health services across countries. In section 3, we present the general equilibrium model that will be used to fit the data. In section 4, we present the data and estimation method we use and report estimates of the model and its predictive performance. In section 5, counterfactual simulations allows us to decompose the cross-country differences in health indicators between the size of the wedges and the elasticities of aggregate to these wedges. We then explore welfare impacts (section 6). Finally, section 7 concludes.

## 2 Price and Quantity Differences Across Countries

Separating price and quantity and in particular constructing a comparable price index for health services is a difficult task. Information systems are different across countries and price information is not always available, in particular in health systems that do not impute all cost to episodes of care. One would also want to compare the same services or the same quantity of services. This is possible for some services but not for others. Finally, different countries use a different mix of

inputs to produce the same output. In Table 1, we report various price estimates that we have been able to gather from studies attempting to compare prices across countries. The International Federation of Health Plans (IFHP, 2013) collects data from private health insurance plans on cost for various procedures and drugs. An angiogram costs 914 dollars in the U.S. compared to 264 in France and 125 in Spain. Hence, the cost in Spain was 13.6% that of the same procedure in the U.S. and 28.8% for France. Similar numbers are obtained for a scan of the abdomen or a bypass surgery. Canada Patented Medicine Prices Review Board (2016) construct a price index for patented drugs in OECD countries (weighted by Canadian sales). The price index reveals substantially lower prices in European countries relative to the U.S. Laugesen and Glied (2011) report information on physician compensation for primary care and for hip replacement. Again, evidence points to higher prices in the U.S. compared to European countries. From OECD Statistics Health data, we find that hospital spending per discharge is also lower in Europe compared to the U.S. (from 27% to 73% of U.S. spending). All this evidence, although imperfect, suggest that prices in the U.S. appear to be larger than in Europe.

Cutler and Ly (2011) investigate administrative costs, given that the U.S. has a distinctive health care system: providers and insurers are typically distinct economic agents. In Figure 1 we report the share of administrative costs in health expenditures (OECD, 2013). In the European countries we consider, we observe lower administrative health care costs than in the U.S.

Price differences reflect both quality or quantity differences in health care services. If so, Americans would be in much better health than their European counterparts. In fact, some evidence suggest that this is unlikely to be the case. In Table 1, we report a measure of efficiency of health services by looking at 5-year cancer survival rates for 4 common cancers: colon, cervical, breast and leukemia. Relative to the U.S., the dispersion in cancer survival rates is very low. Most countries use best treatments and practices with limited dispersion in outcomes. For some cancers, survival rates are lower in Europe while for others, they are higher. On some measures, Americans are using less the health care system (Anderson et al., 2003) while, on others, it appears that the use of medical care is much more intensive in the U.S. (Cutler and Ly, 2011). However, the impact of this intense use of health care in terms of better health remains unclear.

Other factors can explain cross-country differences in health and health expenditures. First, the health insurance system can transfer health services from the richest to the poorest, thus improving

aggregate health status. Second, while higher expenditures may lead to better health, the causality may also run in the opposite direction. The rapid growth of obesity in the U.S. relative to other countries may also explain part of the differences in health expenditures across countries (Thorpe et al., 2004, 2007). According to Cutler et al. (2003), part of the differences in obesity between the U.S. and Europe could originate from differences in food production technology and regulation, which leads to higher relative price of less healthy food choices. Third, it is well known that the U.S. earning risks is larger in European labor markets. This risk has an ambiguous impact on health. A large earning risk may evict health expenditure because agents need to insure themselves against consumption fluctuations (using precautionary savings). However, at the aggregate level, capital accumulation increases output and thus average earnings, which affects the demand for health services and health expenditures as a share of GDP. Hence, in order to estimate the magnitude of health service and efficiency wedges from these observed cross country differences, our model will take into account country-specific co-insurance rate, health behaviors, income process and technology. Hence, we propose a parsimonious heterogeneous agent general equilibrium model that accounts for these factors.

### 3 General Equilibrium Model

#### 3.1 Households

Agents are heterogeneous with respect to their productivity level  $e \in \mathcal{E}$ , health status  $h \in \mathcal{H}$  and asset holding  $a \in \mathcal{A}$ . Let us denote  $e^t$  and  $h^t$  the histories of respectively productivity levels and health status up and until time  $t$ .<sup>4</sup> A Markov process  $\{e \in \mathcal{E}, \tilde{\pi}(e'|e), \tilde{\pi}_0(e_0)\}$  where  $\tilde{\pi}(e'|e)$  is the productivity's transition matrix, and  $\tilde{\pi}_0(e_0)$  its initial value. This Markov process induces distributions  $\tilde{\pi}_t(e^t)$  over time- $t$  histories  $e^t$  and another Markov process  $\{h \in \mathcal{H}, \pi(h'|h, m), \pi_0(h_0, m_0)\}$  induces distributions  $\pi_t(h^t, m_t)$  over time- $t$  histories  $h^t$  for an optimal choice for health service,  $m_t$ . The probability  $\pi(h' = 1|h, m)$  of being in good health ( $h' = 1$ ) next period, given the current health

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<sup>4</sup>It is well known that health expenditures are related to age: older agents spend more on health services. However, in our sample of countries, the age structure cannot be at the heart of the explanation of health outcomes and health expenditures cross-country differences. Indeed, the U.S. have the lowest dependency ratio with the highest share of health expenditures, and Italy the largest dependency ratio, with the smallest GDP share of health expenditures. This leads us to build a parsimonious model that discard life-cycle features, unlike French and Jones (2011), Hugonnier et al. (2013) or De Nardi et al. (2016).



status  $h$ , depends on the choice of health services  $m$ . It can be interpreted as a health production function and probabilities are therefore endogenous. The probability of being in bad health is given by  $\pi(h' = 0|h, m) = 1 - \pi(h' = 1|h, m)$ ,  $\forall h, m$ .

**Preferences.** Households value both their consumption and their health status. Households' preferences can be described by the following standard expected discounted utility

$$\sum_{t=0}^{\infty} \beta^t \sum_{e^t} \sum_{h^t} \tilde{\pi}_t(e^t) \pi_t(h^t, m_t) u(c_t, h_t) \quad (1)$$

where  $0 < \beta < 1$  is the time discount factor,  $c \geq 0$  is consumption. As in [De Nardi et al. \(2010\)](#), health can be either good ( $h = 1$ ) or bad ( $h = 0$ ), therefore  $\mathcal{H} = \{0, 1\}$ . We assume that the instantaneous utility is additive in consumption  $c$  and health  $h$ :

$$u(c, h) = \frac{c^{1-\sigma}}{1-\sigma} + \phi h. \quad (2)$$

with  $\phi > 0$  the utility benefit of good health, and  $\sigma$  is aversion risk parameter.<sup>5</sup>

**From health service expenditures to health status.** Each agent can spend his resources on consumption  $c$  and health services  $m$ . Health services  $m$  improve the probability of being in good health next period. Next period's variables are denoted with a prime. In addition, we assume that the function that maps health services in health status is

$$\pi(h' = 1|h, m) = 1 - \exp(-(\alpha_0 m + \alpha_1 h)). \quad (3)$$

Parameters  $\alpha_{10}$  and  $\alpha_{11}$  are exogeneous and govern both the level and persistence of health, conditional on  $m$ , while  $\alpha_0$  captures the productivity of  $m$ .

**Resource Constraint.** Labor income is affected by an idiosyncratic stochastic process  $e$  that determines the value of efficient labor.<sup>6</sup>  $e$  is the sum of an AR(1) permanent shock with parameters

<sup>5</sup>We pick an additive specification as in [Hall and Jones \(2007\)](#).

<sup>6</sup>Unlike [Grossman \(1972\)](#)'s model, health status does not affect agents' earnings in our model. Indeed, there are different views on the link between wage and health. Grossman favors the view that good health improves productivity and thus wages, but [Rosen \(1974\)](#) underlines that wages must be adjusted upwards to compensate for high health risks (compensating wage differential model). We chose here to be neutral.

$(\rho_e, \sigma_e)$ . Market incompleteness prevents agents from insuring against the idiosyncratic risk. In addition to labor income, agents collect capital income from asset holding  $a$ , with interest rate  $r$ . Next period's asset  $a'$  is then

$$a' = (1 + r)a + we(1 - \tau) - c - \mu pm. \quad (4)$$

Labor income is taxed at a flat-tax rate  $\tau$  which will be used to finance public health expenditures. After-tax income and assets are allocated between consumption  $c$ , health services  $m$  and saving for next period. The relative price of health services with respect to consumption is denoted  $p$  while the co-insurance rate (the fraction of private expenditures in total health expenditures) is denoted  $\mu$ . In addition, assets have to satisfy a borrowing constraint

$$a' \geq 0. \quad (5)$$

**Demand for Health Services and Savings.** For the agent, the state variables are the realizations of the stock of wealth,  $a$ , health status  $h$ , and the household-specific shock,  $e$ . The dynamic program solved by an agent in state  $(a, h, e)$  is

$$V(a, h, e) = \max_{m, c} \left\{ \frac{c^{1-\sigma}}{1-\sigma} + \phi h + \beta \sum_{e'} \tilde{\pi}(e'|e) \left[ \begin{array}{l} \pi(h' = 1|h, m)V(a', h' = 1, e') \\ +(1 - \pi(h' = 1|h, m))V(a', h' = 0, e') \end{array} \right] \right\} \quad (6)$$

subject to equations (4) and (5).  $V$  denotes the agent's value function. The solution of this problem is a set of decision rules that maps the individual state into choices for consumption and health services. We denote these rules by  $\{c(a, h, e), m(a, h, e)\}$ .

### 3.2 The Supply of Health Services

The health sector consists of a provider and a payer. The provider (e.g. a hospital) buys inputs from the good-producing firm in order to transform goods into health services, which are sold to a payer (public and private insurers). The payer buys health services from the provider in order to sell them to households. We focus on two key differences across countries which may explain differences

in prices as suggested by [Cutler and Ly \(2011\)](#): informational frictions and administrative costs.<sup>7</sup> We formalize these differences in a simple framework.<sup>8</sup>

The provider transforms inputs  $b_h$  into health services through the production function  $b = zb_h$  where  $z$  is the productivity of health service producers. Administrative costs in the health system are introduced through sunk costs ( $\iota p_p b$ ), with a fraction  $\iota > 0$  proportional to firm revenue  $p_p b$ , where  $p_p$  is the provider's price. For simplicity, assume that the output of the provider can have a high or a low quality:  $q \in \{0; 1\}$ . When quality is high, the provider supplies the adequate service to a patient and collects profit  $\Pi_b^h = p_p(1 - \iota)b - b_h$ . When the quality is low ( $q = 0$ ), the provider does not provide the adequate service (shirks) but bills to the payer (only incurs administrative costs). When the provider shirks, he collects profit  $\Pi_b^s = p_p(1 - \iota)b$ . The payer can detect shirking behavior with probability  $\zeta \in [0, 1]$ . To maximize profits, the payer will propose an incentive contract such that  $p_p = \frac{1}{\zeta(1-\iota)z}$ .<sup>9,10</sup> In order to avoid the redistribution of the informational rent collected by providers through financial market, we assume that providers support entry costs to enter this market.<sup>11</sup>

The quantity of health services supplied to households is  $m = q(p_p)b$ . Using the equilibrium price contract  $p_p = \frac{1}{\zeta(1-\iota)z}$  that ensures that  $q = 1$  at the equilibrium, we get  $m = q(p_p)b = b$ . The total revenue of the payer is  $pm$ , where  $p$  is the price of health care services paid by households. We assume a competitive market for payers.

**Property 1.** *The price of health services  $p$  increases with administrative costs and informational frictions between providers and payers.*

*Proof.* The zero profit condition leads to  $p = \frac{1}{\zeta(1-\iota)z} \equiv \mathcal{P}(\zeta, \iota)$  with  $\mathcal{P}'_\zeta < 0$  and  $\mathcal{P}'_\iota > 0$ . □

Property 1 shows that the gap between US price  $p_{US}$  and the European price  $p_E$  increases from

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<sup>7</sup>The possibility that information frictions lead to misallocation in the health market was first recognized by [Arrow \(1963\)](#).

<sup>8</sup>For more detailed discussions on this point, see the surveys of [Newhouse \(1996\)](#), [Dranove and Satterthwaite \(2000\)](#) and [Gaynor and Vogt \(2000\)](#), or [Gaynor and Town \(2012\)](#).

<sup>9</sup>As usual in the contract theory, this equilibrium price  $p_p$  is deduced from the equalization of the value of the provider providing high quality services and the one who shirks.

<sup>10</sup>Another way to generate a gap between the effective price and the reservation price  $\frac{1}{z}$  (the production cost), is to introduce bargaining between the payer and the provider. The Nash product is then given by  $(p - p_p)^{1-\zeta}(p_p z - 1)^\zeta$ . In this case, the equilibrium price is  $p_p = \zeta p + (1 - \zeta)\frac{1}{z}$ . The larger the provider's bargaining power ( $\zeta$ ), the higher the price. See [Gowrisankaran et al. \(2015\)](#) or [Ho and Lee \(2017\)](#) for a detailed discussion on the bargaining between providers and payers, in a general framework where insurers bargain also with the consumers.

<sup>11</sup>These costs are paid in goods and are proportional, at the equilibrium, to the size of these firms, measured by their inputs quantities, ie.  $C_I = c_I b_h$  leading to the restriction  $c_I = \frac{1-\zeta}{\zeta}$ .

$\zeta \approx 0$  (the extreme case with infinite informational frictions) to  $\zeta \approx 1$ : the larger the providers' informational rent, the higher the price in countries with informational frictions. The health wedge increases with frictions.<sup>12,13</sup> Moreover, when administrative costs increase, the price of health services increases. This can be the case when the number of operators/intermediaries is uselessly large in the market, perhaps due to the administrative burden of handling the insurance reimbursement process. On the other hand, it is possible that providers in Europe, being in the public sector, are less efficient at producing  $b$  (lower  $z$ ) which would lead to higher prices. In our model, frictions on the supply side of health services generate the health services wedge, implying a price differential between countries.

### 3.3 Good-Producing Firm

Production  $Y$  is characterized by constant returns to scale using aggregate capital  $K$  and labor  $N$  as inputs:

$$Y = AK^\alpha N^{1-\alpha} \quad (7)$$

$A$  captures technological factor productivity (TFP) and  $0 < \alpha < 1$  the capital share in GDP. The firm operates under perfect competition such that profit maximization leads to

$$r = \alpha A \left( \frac{N}{K} \right)^{1-\alpha} - \delta_k \quad (8)$$

$$w = (1 - \alpha) A \left( \frac{K}{N} \right)^\alpha \quad (9)$$

with  $w$  the wage rate,  $r$  the interest rate, and  $\delta_k$  capital annual depreciation rate.

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<sup>12</sup>We can interpret these informational frictions as the imperfectly observed physicians' effort at work by the hospital manager. Then, the larger the physicians' informational rent, the higher the price. This can be consistent with the findings of [Cutler and Ly \(2011\)](#) underlining that specialist U.S. physicians earn 5.8 times what the average worker does, compared to the non-U.S. average of 4.3 times.

<sup>13</sup>In the case where the markup price is determined by a bargaining between payers and providers, two cases can arise: the US system where the provider's bargaining power is large in a decentralized market, and the European case where, in all countries, a public system reduces the provider's bargaining power, by setting the price at its lowest level.

### 3.4 Health Insurance System

Health insurance reimburses medical expenditures using proportional taxes on labor income:

$$\tau w N = (1 - \mu) p \sum_e \sum_h \sum_a m(a, h, e) \lambda(a, h, e) \quad (10)$$

where  $\lambda(a, h, e)$  is the stationary distribution of individuals across individual states  $(a, h, e)$ . Given the co-insurance rate  $\mu$ , the tax rate  $\tau$  must finance expenditures. Using equation (9), we get that tax rate is proportional to the GDP share of health expenditures.

### 3.5 Definition of Equilibrium

A steady-state equilibrium for this economy is a household value function,  $V(a, h, e)$ ; a household policy,  $\{c(a, h, e), m(a, h, e)\}$ ; a health insurance system,  $\tau$ ; a stationary probability measure of households,  $\lambda$ ; factor prices,  $(r, w)$ ; and macroeconomic aggregates,  $K, N$ , such that the following conditions hold:

(a.) Factor inputs, tax revenues, and transfers are obtained aggregating over households:

$$K = \sum_e \sum_h \sum_a a \lambda(a, h, e), \quad N = \sum_j e_j N_j$$

(b.) Given  $K, N$ , factor prices  $r$  and  $w$  are factor marginal productivity ((8) and (9)).

(c.) Given  $r, w$  and  $\tau$ , the household policy solves the households' problem (6).

(d.) Tax rate  $\tau$  adjusts such that health insurance budget constraint (10) is satisfied.

(e.) The goods market clears:  $Y = \sum_e \sum_h \sum_a [c(a, h, e) + pm(a, h, e)] \lambda(a, h, e) + \delta_k K$ , where the equilibrium on health services market implies

$$\sum_e \sum_h \sum_a pm(a, h, e) \lambda(a, h, e) = pb = (1 + c_I) b_h \quad \text{with} \quad c_I = \frac{1 - \zeta}{\zeta}$$

(f.) The price of health services is  $p = \frac{1}{\zeta(1-\iota)z}$ . This sector does not generate profit.<sup>14</sup>

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<sup>14</sup>The zero-profit conditions on the health sector imply that only the consumption of health appears in Equation (4).

(g.) The measure of households  $\lambda(a, h, e)$  is stationary.

## 4 Data and Estimation

We aim to estimate health services and efficiency wedges along with other parameters of the general equilibrium model for countries  $g = 1, \dots, G$ . We follow a two-step method of simulated moments approach. In a first step, a set of common parameters  $(\sigma, \phi, \beta, \alpha_0)$  and U.S. specific parameters  $(\alpha_{10}, \alpha_{11})$  are estimated on U.S. data. In a second step, we estimate wedges (relative to the U.S.) using this set of common parameters, for seven European countries: Sweden, Denmark, the Netherlands, Germany, France, Italy, and Spain. We allow for variation in parameters  $(\alpha_{10}, \alpha_{11})$  across countries to capture unobserved differences in health status (obesity, smoking, etc) and estimate them jointly with wedges. Finally, we allow for considerable heterogeneity in economic resources (income risk  $(\rho_e, \sigma_e)$  and the goods producing technology  $(\alpha, \delta)$ ) as well as health insurance across countries  $(\mu)$ .

The assumption of common preferences is commonly made in macro models estimated across countries (Chari et al., 2007, Ohanian et al., 2008). The assumption that  $\alpha_0$  is also common across countries deserves some discussion. Given information frictions for the supply of health services, differences in the use of inputs ( $b_h$ ) or productivity of medical care ( $z$ ) is reflected in the price that was required in order to induce the provider to provide high quality care. Hence, the assumption that  $\alpha_0$  is common to all countries implies that the ability of any  $m$  to produce  $h$  is the same across countries. The marginal cost of producing good health is given by  $\frac{p}{\pi'_m(h'|h,m)}$  which is country specific despite a common  $\alpha_0$ . Evidence from Table 1 suggest that price dispersion is much larger than dispersion in outcomes (at least for cancer) which is consistent with the assumption of a common  $\alpha_0$  but country-specific  $p$ .

We first describe how auxiliary parameters are set using external information. Second, we use a method of simulated moments to estimate remaining parameters.

### 4.1 Auxiliary Parameters

We use different sources of data to obtain auxiliary parameters. These auxiliary parameters are country-specific.

**Income Risk.** Estimating income processes requires panel data. For the United States, we use eight years of the Panel Study of Income Dynamics (PSID) data (1990 to 1997). Data after 1997 is collected every two years, complicating the estimation of the income process. For European countries, we use eight years of the European Community Household Panel (ECHP) from 1994 to 2001.<sup>15</sup> We first net out the effect of age from income by regressing an household’s total after-tax income on a flexible age polynomial and obtain residuals. We use after-tax household income as it allows for differences across countries in social programs that may mitigate income risk. For the error component, we assume the following process

$$\eta_t = e_t + u_t \quad \text{with} \quad e_t = \rho_e e_{t-1} + \nu_t$$

where  $\nu_t$  is the innovation to the persistent component, distributed  $N(0, \sigma_e^2)$ , whereas the transitory component  $u_t$  is distributed  $N(0, \sigma_u^2)$ . Table 2 shows the estimates of the income process. Overall, the variances of the transitory component are similar. As in French and Jones (2011), we assume this transitory component reflects measurement error and fix it to zero in the model. The estimates of the stationary variance of the permanent component are larger in the U.S. than in European countries. We find considerable persistence in income, with autocorrelation coefficients ranging from 0.9697 (Netherlands) to 0.9798 (Spain). The main source of the difference in income risk is the scale of the innovation to permanent income. The variance of the permanent shock is roughly twice as large in the U.S. compared to Europe.

**Co-insurance rates.** We use average aggregate data from OECD Health Data over the period 1995-2015 to compute the co-insurance rate  $\mu$  across countries and over the period. We define the co-insurance rate as private out-of-pocket household expenditures as a percentage of health expenditures. Table 3 shows estimates of  $\mu$  across countries. Spain and Italy have large share of private (out-of pocket) over total health expenditures, while France and the Netherlands have the smallest shares. The U.S. ranks in the middle.

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<sup>15</sup>Data for Sweden spans a few waves only. Hence, we assign Danish parameters to Sweden. The labor market and the extent of social programs are similar in both countries.

**Technology of the good-producing firms.** We use Penn World Table (Feenstra et al., 2015) in order to estimate the country-specific shares of capital ( $\alpha$ ) and the depreciation rates ( $\delta_k$ ). The values reported in Table 3 give the estimates for the period 1995-2015. The share of capital in production ( $\alpha$ ) is between 0.36 (Denmark) to 0.47 (Italy), the value for the US being 0.384. In the case of the depreciation rate ( $\delta_k$ ), the estimates range between 0.038 (Spain) to 0.048 (US).

## 4.2 Method of Simulated Moments

We have three groups of structural parameters to estimate. The vector of preference parameters is given by  $\{\beta, \sigma, \phi\}$ . Preference parameters are assumed identical across countries. Then, we need to estimate  $\alpha_0$ , the parameter that governs the impact of health expenditures on the probability to be in good health. Finally, we have four country-specific parameters,  $\{A_g, p_g, \alpha_{g,10}, \alpha_{g,11}\}$  for each country  $g$ , capturing *efficiency wedges*, measured by TFP gaps in producing goods ( $A_g$ ), *health services wedges*, measured by price gaps of health services ( $p_g$ ) and exogenous *health risks*, measured the constants  $\{\alpha_{g,10}, \alpha_{g,11}\}$  in the health production function.

The structural parameter vector to estimate is given by

$$\Theta = \{\beta, \sigma, \phi, \alpha_0, \{\alpha_{g,10}\}_{g=1}^G, \{\alpha_{g,11}\}_{g=1}^G, \{A_g\}_{g=1}^G, \{p_g\}_{g=1}^G\}$$

**Method.** Denote the set of country specific auxiliary parameter estimated earlier  $\chi_g$  and  $\chi = \{\chi_1, \dots, \chi_G\}$ . For each country, consider a set of  $M_g$  simulated moments denoted

$$m_g(\Theta_g, \chi_g) = \{m_{g,1}(\Theta_g, \chi_g), \dots, m_{g,M_g}(\Theta_g, \chi_g)\}. \quad (11)$$

while moments from the data are denoted  $m_{g,N}$ . Denote  $W_{g,N}$  a positive definite weighting matrix which depends on the data. We choose a diagonal matrix with elements equal to the inverse of the variance of each moment as a weighting matrix. For moments involving microdata, we use the bootstrap to find the variance while we use the time-series variation to compute the variance for aggregate moments.

We could stack moments of each country and estimate parameters jointly. This procedure is numerically difficult and does not exploit the fact that many parameters are country specific. Since



our objective is to estimate wedges relative to the U.S., we first estimate common parameters  $(\beta, \sigma, \phi, \alpha_0)$ , and  $(\alpha_{US,10}, \alpha_{US,11})$  using a set of U.S. targets:

$$\Theta_{US} = \arg \min [m_{US}(\Theta_{US}, \chi_{US}) - m_{US,N}]' W_{US,N} [m_{US}(\Theta_{US}, \chi_{US}) - m_{US,N}] \quad (12)$$

We then estimate country specific wedges and health risks given these parameter estimates  $\Theta_{US}$ ,

$$\Theta_g = \arg \min [m_g(\Theta_g, \chi_g) - m_{g,N}]' W_{g,N} [m_g(\Theta_g, \chi_g) - m_{g,N}], \quad \forall g \neq US. \quad (13)$$

where  $\Theta_{US} = \{\beta, \sigma, \phi, \alpha_0, \alpha_{US,10}, \alpha_{US,11}\}$  and  $\Theta_{g \neq US} = \{\alpha_{g,10}, \alpha_{g,11}, A_g, p_g\}$ .

Denote by  $D_{g,N}$  the matrix of derivatives of the moment vector relative to parameters for country  $g$ . This can be obtained numerically at the estimated value of the parameters. When using as weighting matrix the inverse of the covariance matrix of the data, the variance of estimates collapses to (Cameron and Trivedi (2005), page 174):  $V_{g,N} = (D'_{g,N} W_{g,N} D_{g,N})^{-1}$ .<sup>16</sup>

**Choice of the moments and identification.** In order to identify structural parameters, we combine a set of aggregate moments and moments derived from micro data. The vector of moments for each country  $g$  is given by

$$\begin{aligned} m_{US} &= \{C/Y, s, \tilde{p}_{1|0}, \tilde{p}_{1|1}, \bar{p}_2, \bar{p}_3, \bar{p}_4\} \\ m_{g \neq US} &= \{\tilde{Y}_g, s_g, \tilde{p}_{1|0,g}, \tilde{p}_{1|1,g}, \bar{p}_{2,g}, \bar{p}_{3,g}, \bar{p}_{4,g}\} \end{aligned} \quad (14)$$

where  $C/Y$  is the ratio of consumption to GDP,  $\tilde{Y}_g$  the GDP per capita relative to US (this moment is not included for the U.S.),  $s_g$  the share of health expenditures as a fraction of GDP,  $\tilde{p}_{1|0,g}$  and  $\tilde{p}_{1|1,g}$  the transition rates from bad to good and good to good health status,  $\bar{p}_{2,g}$ ,  $\bar{p}_{3,g}$  and  $\bar{p}_{4,g}$  the relative probability of being in good health within income quartiles  $i = 2, 3, 4$ , using the first quartile as a base. We define those below.

*In a first stage*, we estimate the 5 parameters using 6 moments on US data. 3 of them, namely  $\{\sigma, \phi, \alpha_0\}$ , are assumed to be the same across countries. Given that it is notoriously difficult to identify  $\beta$  from  $\sigma$  in a heterogeneous agent model, we calibrate the discount factor  $\beta$  using U.S. data provided by Gomme et al. (2011): if we approximate  $\beta$  as  $1/(1 + r/(1 - \tau_k))$  with the after-tax

<sup>16</sup>We have abstracted from first-step noise introduced by the estimation of common parameters in the U.S.

returns  $r \approx 5.16\%$  and the tax rate on capital  $\tau_k \approx 40.4\%$ , we obtain  $\beta = 0.92$ .

The parameter  $\sigma$  is pinned down by targeting  $C/Y$ . Transition rates by health status,  $\tilde{p}_{1|0,US}$  and  $\tilde{p}_{1|1,US}$ , help pin down  $\alpha_{US,10}$  and  $\alpha_{US,11}$ . Parameters  $(\phi, \alpha_0)$  are pinned down by the share of health expenditures in GDP and health transition rates. Consider a simplified static version of the agent's problem to focus on identification of these two parameters:  $m = \arg \max \{\log(y - pm) + \phi h\}$  s.t.  $h = 1 - e^{-\alpha_0 m}$ . Consider two moments, namely  $\{s, h\}$  respectively the share of health expenditures in income and the fraction in good health. The FOC of this problem,  $\frac{p}{y-pm} = \phi \alpha_0 e^{-\alpha_0 m}$  leads to  $\frac{1}{1-s} = \phi \tilde{\alpha}_0 y e^{-\tilde{\alpha}_0 s y}$  with  $\tilde{\alpha}_0 \equiv \frac{\alpha_0}{p}$ . Therefore, one can obtain estimates for  $\{\phi, \tilde{\alpha}_0\}$  using the two following restrictions: *i)*  $h = 1 - e^{-\tilde{\alpha}_0 s y}$  and *ii)*  $\frac{1}{1-s} = \phi \tilde{\alpha}_0 y e^{-\tilde{\alpha}_0 s y}$ . Normalizing  $p = 1$ , we can solve for  $\{\phi, \alpha_0\}$ . The same idea applies to the full model.

*In the second step*, we use cross-country information to pin down relative efficiency, relative health prices and exogenous country-specific health risks. The health transition matrix allows to identify  $(\alpha_{10,g}, \alpha_{10,g})$  in each country  $g$ . GDP per capita relative to US pins down  $A_g$ . As for  $p_g$ , the simplified static problem of the agent is  $m_g = \arg \max \{\log(y_g - p_g m_g) + \phi h_g\}$  s.t.  $h_g = 1 - e^{-\alpha_0 m_g}$ . The FOC leads to the following restriction:  $\frac{1}{1-s_g} = \phi \frac{\alpha_0}{p_g} y_g e^{-\frac{\alpha_0}{p_g} s_g y_g}$ , which can be solved for  $p_g$  provided  $s_g$  and  $y_g$  and estimated  $\phi$  and  $\alpha_0$  from the first-stage. Identification is similar in the full dynamic model. Finally, the health-income gradient provides additional information for identification and allows to check whether the model is able to replicate the variation in the gradient across countries.

**Data.** We use the ratio of consumption to GDP ( $C_g/Y_g$ ) and GDP per capita relative to US ( $\tilde{Y}_g = Y_g/Y_{US}$ ) from Penn World Table (Feenstra et al., 2015) over the years 1995 to 2015. We use real consumption and real GDP per capita at 2011 level National prices (in millions, 2011 US, PPP-adjusted US dollars) to compute  $C/Y$  over the same period. We use information from OECD Health Data for the GDP share of health expenditures ( $s = \frac{pm}{Y}$ ).

We use two longitudinal aging surveys to estimate health state transitions. For the U.S., we use the Health and Retirement Study (HRS, waves 2004 and 2006) while for Europe we use the Survey of Health, Ageing and Retirement in Europe (SHARE, waves 2004 and 2006). We focus on middle age to elderly respondents (age 50 to 75). These surveys use very similar questionnaires and sampling frames. We also use those data to estimate the gradient of health status by levels of

income. We use the existence of limitations with activities of daily living (ADL), which is asked in both surveys. These limitations include whether someone has difficulty with dressing, bathing, getting in and out of bed, eating and walking across a room. Of course, one could be interested in considering multiple dimensions of health but the computational burden of doing this prohibits this possibility. Limitations with activities of daily living is a reliable overall health measure predictive of mortality and use of physician services. It is likely less affected by reporting scale bias than self-reported health (reported from poor to excellent). The probability of not having any ADL is given by  $\tilde{p}_g$  where argument  $g$  denotes country  $g$ . Denote by  $\tilde{p}_{k|j,g}$  the joint probability of being in state  $j$  at time  $t$  and  $k$  at time  $t + 1$ .<sup>17</sup>

To compute the health gradient, we use the distribution of net household income in 2005 PPP adjusted U.S. dollars. We use the quartiles of the distribution within country. We compute the fraction without ADL within each quartile,  $\tilde{p}_{q,g}$  for  $q = 1, 2, 3, 4$ . We use as moments the fraction relative to the first quartile as a base:  $\bar{p}_{q,g} = \tilde{p}_{q,g}/\tilde{p}_{1,g}$  for  $q = 2, 3, 4$ .

**Estimated moments.** We report in Figure 2 moments from the data. GDP per capita is in general 10 to 35% lower in European countries relative to the U.S. ( $\tilde{Y}_g$ ). The U.S. spends 14.7% of GDP on health ( $s_g$ ) while only two countries rise above 10% in Europe (France and Germany). In terms of transition rates into good health, the U.S. ranks last in terms of transition rates to good health irrespective of the origin state (good or bad). Finally, the health gradient by income quartile is much steeper in the U.S. than in any European country.

### 4.3 Estimation Results

#### 4.3.1 Structural Parameters

Estimation results are reported in Table 4. Three parameters are common to all countries  $\{\sigma, \phi, \alpha_0\}$ . Other parameters, prices, TFP and exogenous health risks are country specific.

The coefficient of relative risk aversion,  $\sigma$ , is estimated at 2.113 which lies within the range of estimates found in the literature for precautionary saving models. Hall and Jones (2007) found a very similar value in their study. The marginal utility of being in good health is found to be

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<sup>17</sup>Given that surveys measure health every two years, we recompute annual transition rates, solving  $\tilde{\Pi}_2 = \tilde{\Pi}_1^2$  for  $\tilde{\Pi}_1$  where  $\Pi_q$  is the markov transition matrix for  $q$  year transitions.

0.834. Given the curvature of utility, it implies that health is very valuable. Indeed, the additional utility of being in good health represents 80% of average consumption.<sup>18</sup> The parameter governing the marginal productivity of health investment  $\alpha_0$  is found to be equal at 0.145. This implies an elasticity of health transition from bad to bad health to medical expenditures of -0.5. This lies within the range of micro studies on health production function (see e.g. Romley and Sood (2013)).<sup>19</sup>

In order to gauge the plausibility of our parameter estimates, we compute elasticity of health expenditures  $pm$  to the co-insurance  $\mu$  generated by the model. For the U.S. this elasticity is -0.43 in partial equilibrium (wage, interest rate and taxation are kept constant). This estimate is slightly larger than the elasticity found in the RAND Health Insurance Experiment (-0.2) (Manning et al., 1987) but close to estimates reported by De Nardi et al. (2010) and Fonseca et al. (2020). Our income elasticity estimate of health expenditures  $pm$  is 0.85 which is in the middle of the range of elasticities reported in Gerdtam and Jonsson (2000). In particular, it is close to the value estimated by Acemoglu et al. (2013) which is 0.7 but much lower than Hall and Jones (2007)'s finding (higher than 2).<sup>20</sup> Hence, our estimates do not suggest that health is a luxury good: higher income can not lead to a higher GDP share of health expenditures.<sup>21</sup>

We estimate strong state-dependence in health transition probabilities with the probability of being in good health next period being much larger if one is already in good than in bad health ( $\alpha_{11} > 0 > \alpha_{10}$ ). A similar picture is found across countries. To get an overall picture of the health production function, Figure 3 reports transition probabilities as a function of  $m$  for each country. The variation across countries is driven by exogenous health risks ( $\alpha_{11}, \alpha_{10}$ ) (see Table 5)<sup>22</sup>. When in good health, the health production function estimates suggest that the U.S. has

<sup>18</sup>We compute this number as follows: the expected utility in good health equals the expected utility in bad health if consumption in good health is reduced by 75%. As consumption in good health 6.5% higher than average consumption, we obtain that additional utility of being in good health is 80% of average consumption.

<sup>19</sup>Large number of empirical studies report the impact of medical expenditures on survival rate. We assume that the closest equivalent in our model is the health transition from bad to bad health.

<sup>20</sup>We compute this income elasticity for a one percent change in the equilibrium wage.

<sup>21</sup>With our model, a large GDP share of health expenditures can only be explained by health service wedge ( $\hat{p}$ ). Indeed, simple decomposition of the GDP share of health expenditures  $s$  of the variation sources (income  $y$  or price  $p$ ) is  $\hat{s} = (\epsilon_y - 1)\hat{y} + (1 - \epsilon_p)\hat{p}$ , where  $x \equiv \frac{x_{US} - x_{EU}}{x_{US}}$  and  $\epsilon_x$  for  $x = y, p$  refers to the elasticity of health expenditures to  $x$ . In the data, we observe  $\hat{s} > 0$  and  $\hat{y} > 0$ . Given that the model estimates lead to  $\hat{p} > 0$ ,  $\epsilon_y < 1$  and  $\epsilon_p < 1$ , we have  $\hat{s} > 0$  iff  $\hat{p} > 0$  when  $\hat{y} > 0$ .

<sup>22</sup>In order to provide an economic interpretation to the estimated ( $\alpha_{11}, \alpha_{10}$ ), we compute the probability of being in good health for the estimated model and for a counterfactual model in which heterogeneity in health risks is removed (with ( $\alpha_{11}, \alpha_{10}$ ) set at the average European level). The gap between these probabilities captures the pure effect of health risk heterogeneity. The Spearman correlation between this gap and per-capita alcohol consumption is -0.43. The Spearman correlation between this gap and daily calories supply from OECD health data is -0.33. These correlations have the correct sign providing suggestive evidence of a connection between the exogenous health risk

the lowest probabilities of remaining in good health, for any level of  $m$ . As for the probability of transiting from bad to good health, the U.S. does better and countries such as Denmark do worst. Those transition rates also reveal a kink in the production function. For too low levels of  $m$ , transition probabilities would be negative (per the specification chosen) and so are constrained to zero. At some level of  $m$ , which differs across countries, the marginal productivity of  $m$  becomes positive.

### 4.3.2 Estimated wedges across countries

The estimation procedure allows to measure the cross-country inefficiencies in terms of health prices and TFP (see Table 5): the health service and the efficiency wedges.

In terms of health services wedges, some European countries have much lower prices than the U.S. For example, Italy (0.641), Germany (0.770) and the Netherlands (0.772) have prices which are more than 20% lower than in the U.S. France has prices which are 16.5% lower. Other countries have prices which are quite close to the U.S., Denmark, Sweden and Spain have prices that are statistically and economically similar to those in the U.S. Price differences are smaller than those reported in Tables 1.<sup>23</sup>

The efficiency wedge captures the heterogeneity in economic development across countries. Only Denmark and Germany are statistically more productive (respectively 1.289 and 1.021) while the Netherlands (0.999) appears as efficient as the U.S. The other European countries suffer from a significant lack of efficiency but this gap is small (except for Italy, 0.710).<sup>24</sup>

### 4.3.3 Model fit

Figure 4 shows that the model succeeds in fitting the share of health expenditures ( $s = pm/y$ , the Spearman correlation is 0.93). The model slightly overestimates the transition rate from good to good health ( $p_{11}$ ). In the data,  $p_{11}$  is very similar across countries, which makes it more difficult for the model to fit this dimension. The model still provides a satisfactory fit with a Spearman

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and measures of health risky behaviors.

<sup>23</sup>The Spearman correlation between our measure of price and OECD health price index is 0.31. If we exclude Spain, the correlation goes up to 0.61. Indeed, ASPE (2018) reports that Spain displays the highest price within a set of Medicare drugs in several instances, but Spain never appears as the country offering the cheapest price for these drugs. The Spearman correlation excluding Spain is consistent with this view.

<sup>24</sup>The Spearman correlation between our estimates of the efficiency wedge (relative TFP) with the estimates by the Penn World Tables is 0.43, and goes up to 0.64 with Bergeaud et al. (2016)'s TFP.

correlation between the model’s  $p_{11}$  and its empirical counterpart of 0.69. The model also provides a good fit of the transition from bad to good health (the Spearman correlation is 0.79 for  $p_{10}$ ). The model matches the fact that the U.S. is the country where health inequalities are the largest, whereas the Netherlands is the country where they are the lowest. The income-health gradient at quartile 4 is satisfactory (the Spearman correlation is 0.5). With respect to the other income-health gradients, the data does not display enough heterogeneity, which makes it more difficult for the model to fit this dimension. Finally, the GDP differences are well reproduced (the Spearman correlation is 0.97 for  $Y$ ).

## 5 Explaining Variation in Health Expenditures and Health Across Countries

The price of health services is approximately 15% larger in the U.S. than in Europe while technological efficiency is 5% higher in the U.S. than in Europe. Our estimation results also reveal that heterogeneity in exogenous health risks is important.

To quantify the effect of these differences, we focus on the GDP share of health expenditures ( $s$ ), the fraction of individuals in good health ( $p(h = 1)$ ) and health inequalities (income-health gradient) measured by the relative fraction of individuals in good health within the fourth income quartile ( $\bar{p}_4$ ). We simulate counterfactual general equilibrium scenarios where we neutralize each of heterogeneity sources in turn. Table 6 reports results. We consider four scenarios: *i*) a baseline scenario where all country specific heterogeneity is accounted for, *ii*) a scenario where we remove price heterogeneity, setting the health price wedge equal to the European average, *iii*) a scenario where efficiency heterogeneity is removed, setting the efficiency wedge equal to the European average, *iv*) a scenario where exogenous health risks heterogeneity ( $\alpha_{11}, \alpha_{10}$ ) is removed, setting exogenous health risks equals to their European averages.<sup>25</sup> In order to highlight the U.S.-Europe differences, we report the European averages of these indicators.

The baseline differences ( $\Delta$ ) between the U.S. and the E.U. countries are 0.064 for  $s$  and -0.059

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<sup>25</sup>Given that the characteristics of the production function of the U.S. goods ( $\alpha, \delta$ ), as well as the co-insurance rate ( $\mu$ ), are close to the average of their European counterparts, they can not explain why our model can explain the differences between the U.S. and the European countries. In addition, the experiment in which we remove heterogeneity in income process ( $\rho_e, \sigma_e$ ) yields results that are similar to the removal of heterogeneity in TFP. For the sake of brevity, we will not report them below.

for  $p(h = 1)$ . The U.S. spends more but has lower health. As for inequalities, they are also higher than in Europe, with a difference in the health gradient ( $\bar{p}_4$ ) equal to 0.212.

### 5.1 The impact of macroeconomic wedges: health service prices and efficiency

When heterogeneity in the health service wedge is removed ("price" scenario), the gap in expenditures is reduced by 20.3%, going from 0.064 to 0.051, and the gap in the fraction of individual in good health is reduced by 28.8%, going from 0.059 to 0.042. Beyond its estimated size, the health service wedge has a quantitatively sizeable effect on health expenditures and health status differences across countries. This wedge has also a sizeable impact on health inequalities: by removing this wedge, the gap in income-health gradient is reduced by 29.25%, going from 0.212 to 0.15.

When the efficiency wedge heterogeneity is removed ("efficiency" scenario), the GDP share of health expenditures increases marginally in the U.S. by 0.003. But, it also increases marginally in European countries by 0.004. This last result is driven by the large decline in TFP in Denmark, the only country where the TFP is higher than in the U.S. Without this country, the gap between a high-TFP country (the U.S.) and a group of countries characterized by a low-TFP (all the E.U. countries except Denmark) unambiguously increases. This result is in line with our result that the income elasticity of health expenditures is below one. The GDP share of health spending is declining in TFP. The U.S. is found in this study, but also in others (e.g. [Ohanian et al. \(2008\)](#)), to have higher TFP (except for Denmark). Therefore, technological efficiency cannot explain why the U.S. has a higher GDP share of health expenditures in this model. With a homogeneous efficiency wedge, health inequality increase by 10%, from 0.212 to 0.233, suggesting that this wedge cannot explain differences in health inequalities between the U.S. and Europe.

### 5.2 The impact of microeconomic risks: health

Worse health status in the U.S., for example due to higher prevalence of risky behaviors, could also explain differences in expenditures and health status ([Thorpe et al., 2004, 2007](#)). For example, the rapid growth of obesity in the U.S. relative to other countries could play a role ([Cutler et al., 2003](#)). In the model, these are captured by exogenous health risks ( $\alpha_{10}, \alpha_{11}$ ). When the heterogeneity in exogenous health risks is removed ("health risks" scenario), differences across countries in health expenditures, health status and health inequalities decrease sharply. The gaps in expenditures

virtually disappears, going from 0.064 to 0.002. At the same time, the gap in the fraction of individual in good health is reduced by 79.6%, going from -0.059 to -0.012 and the gap in income-health gradient is by 66.5%, from 0.212 to 0.071. This country-specific health risks play a sizeable role in accounting for differences between the US and Europe due to a simple mechanism. A large proportion of Americans are in good health. However, they face a high probability of getting sick (relative to Europe), so they spend more on medical care than their European counterparts, which leads to a high U.S. GDP share of health expenditure. This additional spending on health care does not compensate for the larger U.S. exogenous health risk, which leads the model to fit the larger U.S. GDP share of health expenditures without better health outcomes.

This decomposition of differences between the U.S. and the E.U. countries with respect to GDP share of health expenditures, fraction of individuals in good health and income-health gradient suggests that both the health services wedge and exogenous health risks explain most of the cross-country gap while TFP differences cannot rationalize these gaps.

## 6 Welfare Consequences of the Health Services Wedge

### 6.1 Lifetime Cost-of-Living Index

We perform a counterfactual exercise in which Americans pay the average European health price.<sup>26</sup> We then ask the question: What would Americans be willing to pay to switch to the average European price? We can compute the Willingness-to-pay (WTP) for each agent  $(a, h, e)$  for accessing an economy where the health services wedge is the same than in Europe. Using the model, we compute the welfare of each  $(a, e, h)$ -type agent in the U.S. economy  $V(a, h, e|p_Z, \Omega_{US}^X)$ , which depends on wedge values  $(p_{Z=US,EU})$  and on  $\Omega = \{\Omega_{US}^X\}_{X=US,EU}$ , a set of two vectors regrouping *(i)* all US-specific characteristics (income risk, risky health behaviors, co-insurance rate) and *(ii)* equilibrium factor prices  $(r(p_X), w(p_X))$  and tax rate  $(\tau(p_X))$ .<sup>27</sup> When  $Z = EU$ , if  $X = US$ , the values are evaluated in partial equilibrium (PE), whereas if  $X = EU$ , they take into account general equilibrium (GE) adjustments of interest rate, wage rate and taxation. Therefore, the state

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<sup>26</sup>To simplify the presentation, we present computations of welfare cost of price wedges. The welfare computations related to the efficiency wedge ( $A$ ) is identical, except for the index of the cost-of-living which is not defined without endogenous labor supply.

<sup>27</sup>With  $\Omega_{US}^{US}$ , input prices  $(w, r)$  and tax rate  $\tau$  are taken at their general equilibrium values with  $p_{US}$ . This implies that we restrict the analysis to partial equilibrium approach when  $p = p_{EU}$  but  $\Omega = \Omega_{US}^{US}$ .



contingent transfers  $\mathcal{P}^X(a_t, h_t, e_t)$  that keep agents indifferent between two price regimes,  $p_{US}$  vs.  $p_{EU}$ , is given by:<sup>28</sup>

$$V(a_t + \mathcal{P}^X(a_t, h_t, e_t), h_t, e_t | p_{US}, \Omega_{US}^{US}) = V(a_t, h_t, e_t | p_{EU}, \Omega_{US}^X) \quad X = US, EU.$$

The transfer  $\mathcal{P}^X(a_t, h_t, e_t)$  can be spent as agents choose in time and across goods. While this transfer is informative about the welfare effect of a change in price, it does not convey much information on the additional cost-of-living of an agent paying the price  $p = p_{US}$ , after controlling for the same welfare as in an economy where  $p = p_{EU}$ . To see this, let us define the lifetime expenditure function  $\mathcal{E}$  as follows

$$\mathcal{E}(p_{US}, \bar{V}_t | h_t, e_t) = \min a_t \quad \text{s.t.} \quad V(a_t, h_t, e_t | p, \Omega) \geq \bar{V}_t$$

where  $\bar{V}_t$  is some reference value of utility. For an optimal sequence of choices (consumption and health expenditures), the intertemporal budget constraint allows us to obtain  $\mathcal{E}(p_{US}, \bar{V}_t | h, e)$  as follows

$$\begin{aligned} & \sum_{\tau=0}^{\infty} \sum_{e^{t+\tau}} \sum_{h^{t+\tau}} \tilde{\pi}_t(e^{t+\tau}) \pi_t(h^{t+\tau} | p_{US}) \mathcal{R}_{US}^\tau [c(h^{t+\tau}, e^{t+\tau} | p_{US}) + \mu p_{US} m(h^{t+\tau}, e^{t+\tau} | p_{US})] \\ &= a_t + \mathcal{P}^{EU}(a_t, h_t, e_t) + \sum_{\tau=0}^{\infty} \sum_{e^{t+\tau}} \tilde{\pi}_t(e^{t+\tau}) \mathcal{R}_{US}^\tau (1 - \tau(p_{US})) w(p_{US}) e^{t+\tau} \\ \Leftrightarrow & \mathcal{E}(p_{US}, V(a_t, h_t, e_t | p_{EU}, \Omega_{US}^{EU}) | h_t, e_t) = a_t + \mathcal{P}^{EU}(a_t, h_t, e_t) + \mathcal{G}_{US}(e_t) \end{aligned} \quad (15)$$

where  $\mathcal{R}_{US} = \frac{1}{1+r(p_{US})}$  is the discount rate,  $\mathcal{G}_{US}(e_t)$  the human wealth<sup>29</sup> and  $\mathcal{E}(p_{US}, \bar{V}_t, \Omega_{US}^{EU}) | h_t, e_t$  the lifetime expenditures allowing to reach the targeted welfare  $\bar{V}_t = V(a_t, h_t, e_t | p_{EU}, \Omega_{US}^{EU})$  in an economy where  $p = p_{US}$ . When the agent faces price  $p_{EU} < p_{US}$ , her optimal lifetime expenditures

<sup>28</sup>A change in the price of health services leads to a new value function:  $V(a, h, e | p_{EU}, \Omega_{US}^{EU})$  in general equilibrium, and  $V(a, h, e | p_{EU}, \Omega_{US}^{US})$  in partial equilibrium. Notice that  $p_{US} > p_{EU}$  implies  $V(a, h, e | p_{US}, \Omega_{US}^{US}) < V(a, h, e | p_{EU}, \Omega_{US}^{EU})$ . Indeed, in partial equilibrium, input prices do not change and we trivially have  $V(a, h, e | p_{US}, \Omega_{US}^{US}) < V(a, h, e | p_{EU}, \Omega_{US}^{US})$ . In general equilibrium, a lower health price wedge reduces the tax rate ( $\tau(p_{US}) > \tau(p_{EU})$ ). This increases the capital-output ratio and thus the wage rate  $w$ , thereby magnifying the increase in value functions following the health price change.

<sup>29</sup>Let  $\vec{e}$  be the vector of productivity. The human wealth  $\mathcal{G}_X(e)$  is defined by

$$\mathcal{G}_X(e) = (1 - \tau(p_X))w(p_X)e + \mathcal{R}_X \Pi_e \mathcal{G}_X(e') \quad \Rightarrow \quad \mathcal{G}_X = (1 - \tau(p_X))w(p_X)[Id - \mathcal{R}_X \Pi_e]^{-1} \vec{e}$$

required for her to reach the same welfare  $\bar{V}_t = V(a_t, h_t, e_t | p_{EU}, \Omega_{US}^{EU})$  is  $\mathcal{E}(p_{EU}, \bar{V}_t | h_t, e_t)$ . We can deduce this second lifetime expenditures function from the agent's budget constraint:

$$\begin{aligned}
& \sum_{\tau=0}^{\infty} \sum_{e^{t+\tau}} \sum_{h^{t+\tau}} \tilde{\pi}_t(e^{t+\tau}) \pi_t(h^{t+\tau} | p_{EU}) \mathcal{R}_{EU}^{\tau} [c(h^{t+\tau}, e^{t+\tau} | p_{EU}) + \mu p_{EU} m(h^{t+\tau}, e^{t+\tau} | p_{EU})] \\
&= a_t + \sum_{\tau=0}^{\infty} \sum_{e^{t+\tau}} \tilde{\pi}_t(e^{t+\tau}) \mathcal{R}_{EU}^{\tau} (1 - \tau(p_{EU})) w(p_{EU}) e(e^{t+\tau}) \\
\Leftrightarrow & \mathcal{E}(p_{EU}, V(a_t, h_t, e_t | p_{EU}, \Omega_{US}^{EU}) | h_t, e_t) = a_t + \mathcal{G}_{EU}(e_t)
\end{aligned} \tag{16}$$

Equation (16) provides the cost of lifetime expenditures at general equilibrium when  $p = p_{EU}$ , whereas equation (15) pins down the cost of lifetime expenditures at general equilibrium when  $p = p_{US}$ , given that the agent enjoys the same welfare in the two cases. The gap between these two expenditure functions provides a measure of the lifetime cost-of-living in the U.S. Indeed, using (15) and (16), we can define a lifetime cost-of-living index as follows:

$$I_{LT}(a, h, e) \equiv \frac{\mathcal{E}(p_{US}, \bar{V}(a, h, e) | h, e)}{\mathcal{E}(p_{EU}, \bar{V}(a, h, e) | h, e)} 100 = \frac{a + \mathcal{G}_{US}(e) + \mathcal{P}^{EU}(a, h, e)}{a + \mathcal{G}_{EU}(e)} 100 \tag{17}$$

where the numerator measures the total resources needed to reach  $\bar{V}$  in a economy where  $p = p_{US}$  and the denominator measures the total resources needed to reach the same welfare ( $\bar{V}$ ) but in an economy where  $p = p_{EU}$ . When  $I_{LT} > 1$ , the lifetime cost-of living is higher in the economy where  $p = p_{US}$  than in an other where  $p_{EU}$ .

This index is different from the Laspeyres index which would be defined in the case of our experiment as follows  $I_L = \frac{c_{US} + \mu p_{US} m_{US}}{c_{US} + \mu p_{EU} m_{US}}$  where  $c_{US}$  and  $m_{US}$  are the average values of consumption and health expenditures. This index suffers from several limitations: *i*) it is valid only in a static environment, *ii*) does not allow for substitution and hence does not keep utility constant, *iii*) assumes a representative agent and *iv*) an economy without uncertainty. Moreover, one also needs to account for general equilibrium adjustments: a change in health price induces changes of other equilibrium prices (wages, interest rate).<sup>30</sup> Berndt et al. (2001) discuss various of these shortcomings in the context of constructing a price index for medical services. As Berndt et al. (2001) discuss, a theoretically grounded cost-of-living index would account for the production of health (health

<sup>30</sup>After the health price reduction of 15%, the tax rate is reduced by 0.7 pp, inducing a increase in after-tax wage of 0.5% (less distortions), even if the wage is reduced. Remark that the interest rate increases by 0.04pp.

market services, health insurance and ability of individuals to use care for being in good health) and consumption of health services (preferences and budget). Using Hicksian measures of cost-of-living, first proposed by Konüs (1924), our measure provides a simple monetary metric that measures the welfare costs of inefficient health services as a cost-of-living index in a general equilibrium model with heterogeneous agents faced with idiosyncratic uncertainty. We aggregate the lifetime cost-of-living index by using the agents' distribution obtained in general equilibrium for the benchmark economy, here the US economy with  $p_{US}$ . Therefore, the average ideal price index is given by

$$I_{LT} = \sum_a \sum_e \sum_h \lambda(a, e, h | p_{US}, \Omega_{US}^{US}) I_{LT}(a, e, h)$$

## 6.2 Quantitative results

Table 7 reports lifetime cost-of-living indices in the U.S. induced by the health service wedge. We do these calculations both under partial (PE) and general equilibrium (GE) and report the indices for agents in bad and good health as well as for three different levels of income ( $e_0$  lowest income,  $e_4$  middle income and  $e_9$  highest income level). We also report the average lifetime cost-of-living index.

Our estimates of the average lifetime cost-of-living index are respectively 101 with GE adjustments and 100.39 at PE. The cost-of-living index using GE effects is larger than the Laspeyres index (100.36).<sup>31</sup> Because the fall in the health service wedge can generate GE adjustments with a reduction in the tax needed to finance health insurance, but also an increase in the after-tax incomes, the cost-of-living impact of lower prices is underestimated by a PE approach. Indeed, in PE, the WTP measured as a fraction of the initial total wealth is equivalent to  $I_{LT} - 100$ . In contrast, when input prices and tax adjustments raise households' purchasing power (in GE), a high health service wedge increases the cost of living in the U.S. by reducing all market opportunities: with GE effects, the impact on the U.S. lifetime cost-of-living is twice as large than in PE or with the Laspeyres index.

<sup>31</sup>A measure of the cost of living with U.S. health price versus the European health price is provided by the Laspeyres index:

$$\frac{c_{US} + \mu p_{US} m_{US}}{c_{US} + \mu p_{EU} m_{US}} 100 = \frac{\frac{c_{US}}{y_{US}} + \mu \frac{p_{US} m_{US}}{y_{US}}}{\frac{c_{US}}{y_{US}} + \mu \frac{p_{EU} m_{US}}{p_{US} y_{US}}} 100 = \frac{0.79 + 0.13 \times 0.15}{0.79 + 0.13 \times 0.85 \times 0.15} 100 = 100.36$$

where  $s$  is 0.15, 0.79 is the observed consumption share of GDP in the U.S. over the period 1992-2008 and 0.85 is the average relative price of health services in Europe. This index would suggest that inefficient health services impose an additional cost-of-living in the U.S. of 4 tenth of a percentage point.

Table 7 also shows that low-income agents are the least impacted by the health services wedge. They consume less health than high-income agents. On the other hand, high-income agents are less affected by GE adjustments. As a result, a larger portion of their gain come from behavioral responses in PE.<sup>32</sup> In contrast, the low-income agents benefit from the health service wedge reduction only through tax reduction and wage increase.<sup>33</sup> We find strong effects of GE adjustments which redistribute resources to financially constrained agents.

In Table 7, we also disaggregate by health status to quantify heterogeneous effects. We estimate that the health service wedge leads to an additional cost-of-living of 1.01 % (0.85 %) for low-income agents (high-income agents) in good health while it increases by 1.07 % (1.39 %) for a low-income agents (high-income agents) in poor health. These additional costs supported by agents in poor health are amplified by GE adjustments: in PE, the costs paid by an individual in poor health are equal to those paid by agents in good health, whereas they are six percents larger when GE adjustments are accounted for.

Figure 5 shows the willingness to pay for reducing the health services wedge in the U.S. for each type of agent  $(a, h, e)$ . The concavity of the value function implies that the WTP increases with the level of agent's asset (see panels (a)-(c) of Figure 5): a positive gap in the welfare must be compensated by a larger wealth increase when the asset level is large. The WTP is higher for agents with a higher propensity to consume medical care. Because the high-income agents have the highest propensity to consume higher medical care, they also have the highest WTP. For each asset level, the WTP is larger for agents in poor health, underlying their need for health services and therefore their larger willingness to pay for a reduction in health prices. Finally, by reducing the taxation needed to finance less expensive health care, the general equilibrium adjustments make it possible to increase the resources of all agents. However, these variations in labor incomes are all the more profitable as agents have low labor income, since labor income represent a much larger fraction of their total income. In general equilibrium, the reduction of the health services wedge leads to a reduction in welfare inequalities.

As a point of comparison, we compare the monetary impact of the two wedges (health services

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<sup>32</sup>In PE, only the health service wedge change. Low-paid workers, with a small level of asset, are not willing to pay for the price change because they do not consume health services and face low earning mobility.

<sup>33</sup>In GE, even if low-income agents do not consume health services, they are willing to pay for a change in the U.S. health service wedge because they will benefit from the tax reduction and the wage increase.

and efficiency) by looking at the willingness-to-pay (WTP) for each agent for accessing an economy where the health service wedge **or** the efficiency wedge are the same than in Europe. In Figure 6, we show that the impact of reducing TFP in the U.S. by 5% (the European average of the efficiency wedge), is much larger and implies a negative WTP (willingness-to-accept) of more roughly 3 consumption units, 1.5 times larger than the impact of the health services wedge (see Figure 5). This larger impact of the efficiency wedge comes from the large direct impact of TFP on goods consumption of all agents. But adjusting for the budget share of health expenditures, the health services wedge has a quantitatively sizeable impact.

## 7 Conclusion

Health expenditures as a share of GDP and health status vary significantly across countries. In this paper, we evaluate the contributions of two inefficiency wedges on the cross-country differences in the GDP share of health expenditures and health status: *(i)* the efficiency wedge measuring the delay in adoption new technology in the producing goods sector (TFP gaps), and *(ii)* the health service wedge capturing the inefficiencies on the health service market.

To this end, we extend a general equilibrium framework à la [Aiyagari \(1994\)](#) by including health production ([Grossman, 1972](#)). Beyond to estimate structural parameters (preferences and health production) using the method of simulated moments based on macro and micro data from the U.S. and seven European countries, our structural approach allows us to identify these country-specific wedges, after taking into country-specific risks (income risk and production function, health risk and co-insurance rate).

If the U.S. is the one of the most efficient for producing goods, is is also the country where the distortions of the health services price are the largest. We estimate than the unit cost of health expenditures is 15% larger for an American than a European. We show that efficiency wedge cannot account for cross-country differences in health expenditures and health outcomes. Using counterfactuals, we find that when health price distortions in the U.S. have the same order of magnitude as in Europe, the gap in health expenditures is reduced by 20%, accompanied by a reduction in gap for the fraction of individuals in good health by 30%. Reducing the price distortion would result in a fall in US income-health gradient by 30% at quartile four.

When we consider welfare, we estimate that the extra cost-of-living induced by the U.S. health service wedge is 1 percentage point in life-time expenditures on average. The willingness-to-pay of Americans to access European healthcare prices is only one and a half times smaller than the transfer that we should give them so that they accept to live with the European technological level. Our general equilibrium approach also underlines that the reduction of the inefficiency on the health market allows the high-income agents to be the largest winners because they are the largest consumers of health services. Low-income agents still benefit from the fall in health prices through general equilibrium effects, with the lower taxation and increase in after-tax wage. This result underlines that low-income agents pay for the current U.S. health system, through taxation and large price distortions, while they are the ones who use less health services.

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## A Solving the General Equilibrium Model

**Step 1: Households' decision rules.** In step 1, we compute the household optimal policies. Given  $r, w, \tau, \mu, p$ , we determine, for each state  $(a, h, e)$ , consumption, savings and medical expenditures  $\{c(a, h, e), a'(a, h, e), m(a, h, e)\}$  that solve the households' decision problem described in (6). We rely on a discrete approximation of the state space.  $h$  takes 2 values (good or bad), the number of  $e$  ability level is  $N_e$  and the asset grid is captured by a discrete set of points  $N_k$ . We then compute  $2 \times N_e \times N_k$  value functions. Let us make several comments on the asset grid. First, we use piecewise linear interpolation, so that next period's asset choice can lie outside the initial grid on asset. Secondly, as it is standard in the literature (Castaneda et al. (2003)), the asset grid is not equally spaced. For very low values of asset holdings, the distance between grid points is small. This is done to allow financially constrained individuals to increase their savings by small increments.

With respect to Aiyagari (1994)'s model, the complexity lies in the computation of two optimal choices  $c$  and  $m$  ( $a'$  being determined by the household's budget constraint) that are related through a dynamic first-order condition. We rely on value function iteration. Starting from a guess on optimal choices of  $c$  and  $m$ , for a given state  $(a, h, e)$ , using Nelder-Mead optimization, we compute values of  $c$  and  $m$  that maximize the value function (6), using a guess on next period's value function. The new values for  $V, c$  and  $m$  are compared to the initial guess. If they are not close, replace the guess by the new values of  $c, m, V$  and repeat the optimization procedure. If they are close enough, the household's policy was found for the given state  $(a, h, e)$ . We then repeat the whole process for all possible values of state  $(a, h, e)$ .

**Step 2: Stationary distribution.** We compute the invariant wealth and health distribution over a blown-up grid using interpolation. The vector of state probabilities over the states  $(a, h, e)$  is updated using optimal policies and transition probabilities for shocks. The process is repeated until the vector of state probabilities becomes invariant.

**Step 3: General Equilibrium.** We compute the general equilibrium factor prices ( $r$  mentioned in (b.) in Section 3.5) then  $w$  is inferred from equation (9) and the equilibrium tax rate  $\tau$  (mentioned in (d.) in Section 3.5). As a result, Steps 1 and 2 must be repeated until the interest rate  $r$  clears

the asset market and the tax rate  $\tau$  ensures that health insurance budget constraint is satisfied. When performing estimation, we omit the tax loop. Since we target  $s$  and hit it consistently across countries, the tax rate can be set at the value consistent with the target. This speeds up the estimation algorithm. When simulating counterfactuals, we allow taxes to adjust.

The steps of the algorithm are then

- i. Compute the stationary level of employment  $N$
- ii. Make an initial guess of the interest rate  $r$  and tax rate  $\tau$
- iii. Compute the wage rate  $w$  using equation (9)
- iv. Compute the household's decision rules (Step 1)
- v. Compute the invariant distribution (Step 2)
- vi. Calculate aggregate variables using the agents distribution. Check market clearance on the asset market. Check that health budget constraint is satisfied. If these conditions do not hold, update the guess of the interest rate  $r$  and tax rate  $\tau$ . If not, go back to ii.
- vii. Check for convergence and update the guess

# Figures

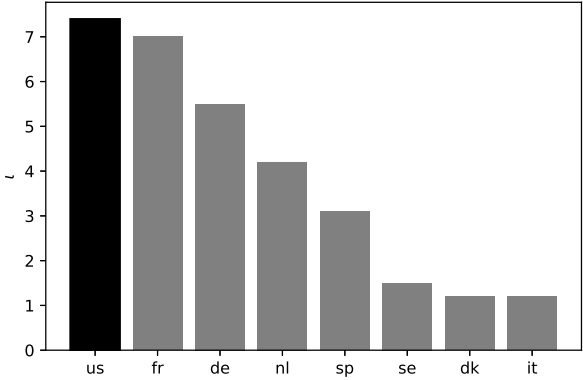
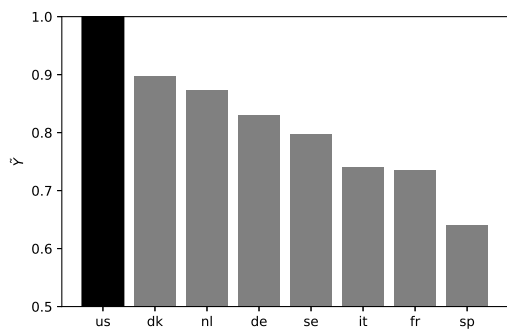
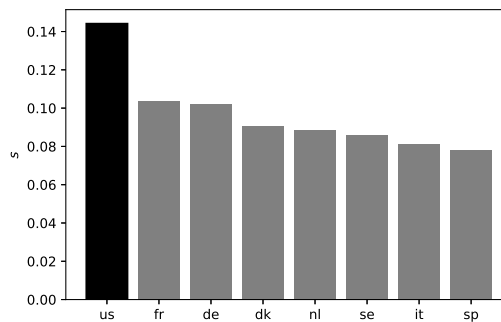


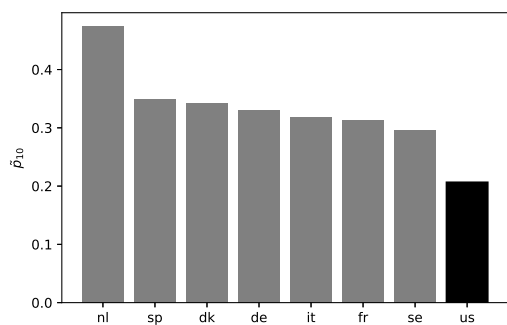
Figure 1: Share of administrative costs in health expenditures: (OECD, 2013).



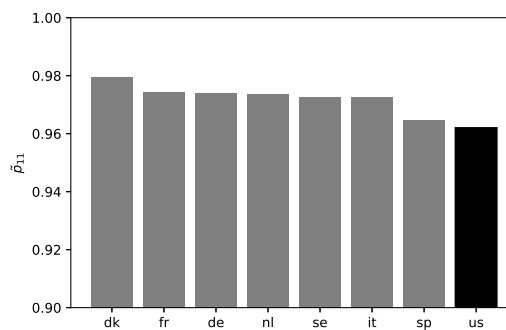
(a) Relative GDP per capita



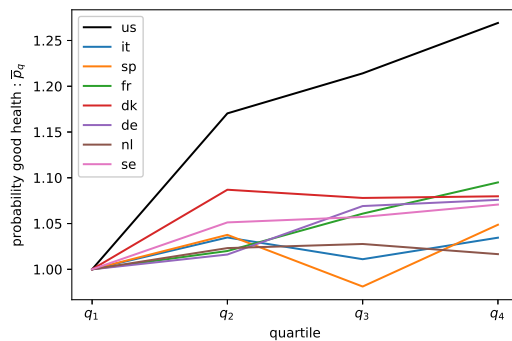
(b) GDP share health expenditures



(c) Transition from Bad to Good Health



(d) Transition from Good to Good Health



(e) Health-Income Gradient

Figure 2: **Moments used in Estimation:** See text for description of how each moments was constructed.

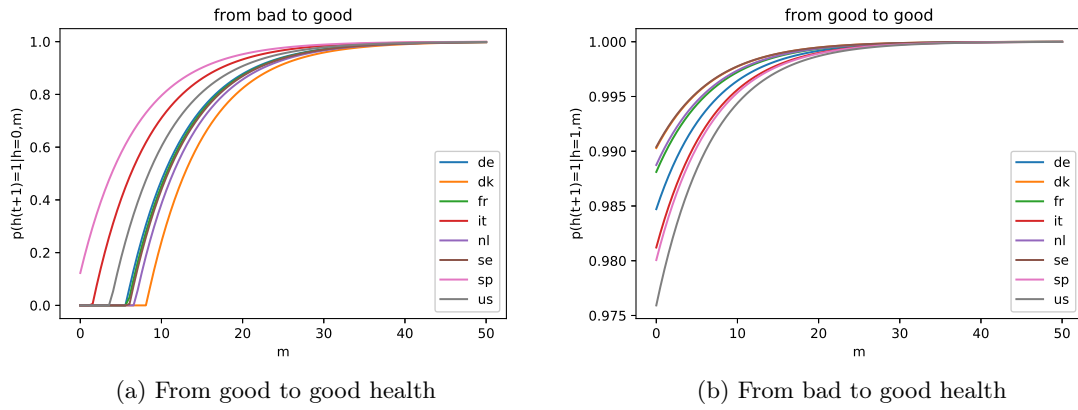
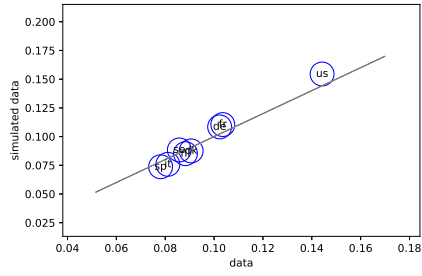
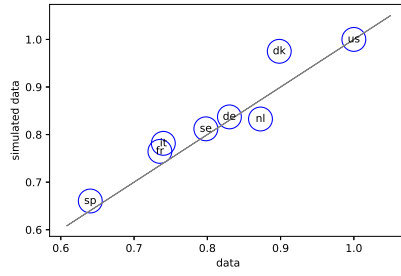


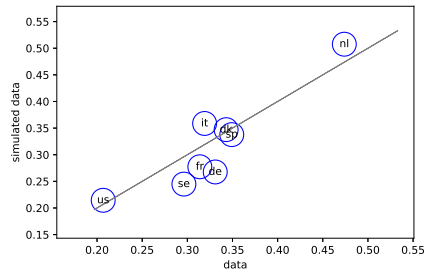
Figure 3: **Kinks in the production function:** Estimation results for the health production function across countries. Estimates produced conditional on being in good (left panel) and bad health (right panel).



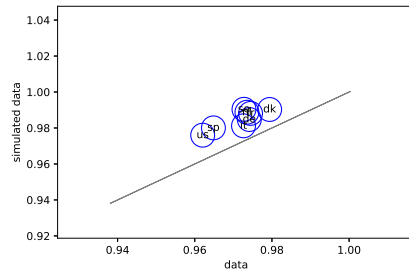
(a) GDP share of health exp.  $s = \frac{pm}{Y}$



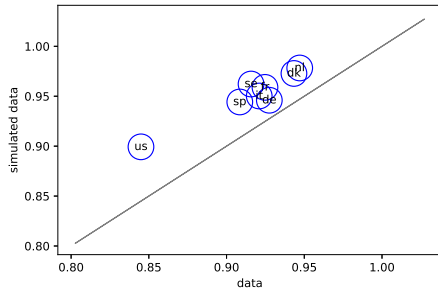
(b) Relative GDP per capita  $\tilde{Y}$



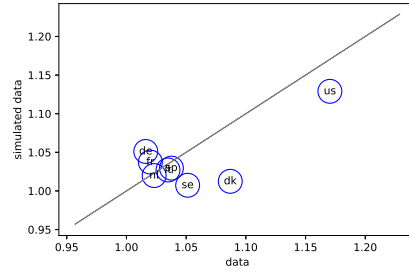
(c) Transition bad to good health  $\tilde{p}_{10}$



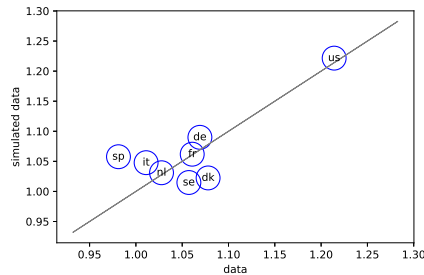
(d) Transition goog to good health  $\tilde{p}_{11}$



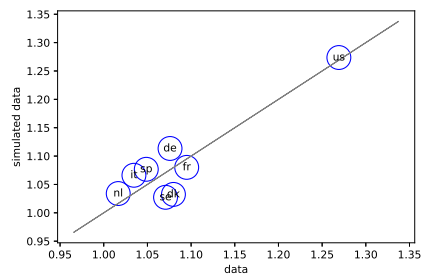
(e) Fraction in good health  $\tilde{p}_1$



(f) Income-health gradient  $\bar{p}_2$



(g) Income-health gradient  $\bar{p}_3$



(h) Income-health gradient  $\bar{p}_4$

Figure 4: **Comparison of Simulated Moments and Data:** The Y axis measures the simulated moments and the X axis moments from the data. The 45 degree line indicates a perfect fit. Each circle denotes the pair of simulated and data moments for each country.



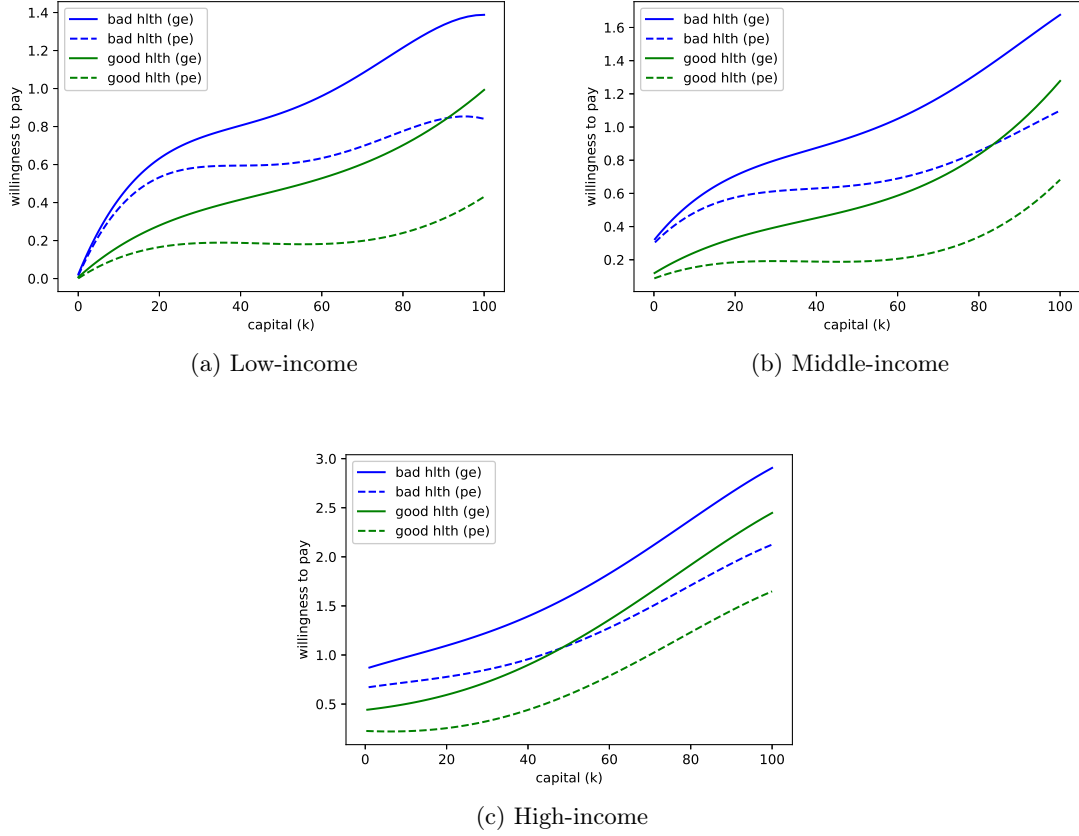


Figure 5: **Willingness-to-Pay for a Reduction in the Health Services Wedge:** For the U.S., we report the willingness-to-pay for a reduction in the price of health services. We do this for three types of agents: low-income ( $e = 0$ ), middle-income ( $e = 4$ ) and high-income ( $e = 9$ ). For each, we compute the willingness-to-pay as a function of health status ( $h = 0$  for bad health and  $h = 1$  for good health) and assets  $a$ . The willingness-to-pay is reported in consumption units in partial equilibrium (dotted line) and general equilibrium (solid line).

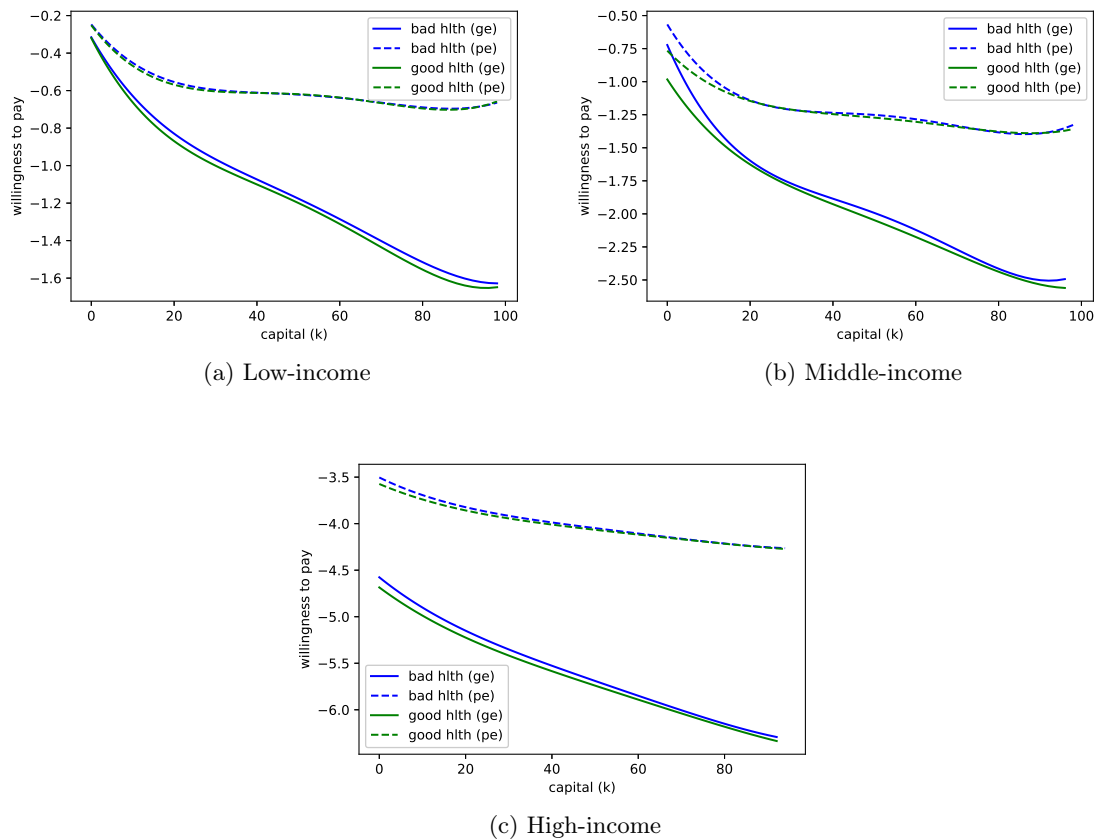


Figure 6: **Willingness-to-Pay for a Reduction in the Efficiency Wedge:** For the U.S., we report the negative willingness-to-pay (willingness-to-accept) for a reduction in the TFP. We do this for three types of agents: low-income ( $e = 0$ ), middle-income ( $e = 4$ ) and high-income ( $e = 9$ ). For each, we compute the willingness-to-pay as a function of health status ( $h = 0$  for bad health and  $h = 1$  for good health) and assets  $a$ . The willingness-to-pay is reported in consumption units in partial equilibrium (dotted line) and general equilibrium (solid line).

## Tables

	US	DE	DK	FR	IT	NL	SE	SP
<b>Prices</b>								
Angiogram	914			264				125
relative US	1			0.288				0.136
Scan abdomen	750	319		248		258		161
relative US	1	0.425		0.33		0.344		0.214
Bypass surgery	73420			22344		14061		17437
relative US	1			0.304		0.191		0.275
Drug price index	1	0.34		0.268	0.285	0.272	0.306	0.275
relative US								
Primary care physician fee								
Public payer	60	46		32				
relative US	1	0.76		0.53				
Private payer	133	104		34				
relative US	1	0.78		0.25				
Physician fee for hip replacement								
Public payer	1634	1251		614				
relative US	1	0.76		0.41				
Private payer	3996			1340				
relative US	1			0.33				
Hospital spending per discharge	18142	5072	11112	5201		13244	9870	
relative US	1	0.27	0.61	0.28		0.73	0.54	
<b>Efficiency</b>								
Five-year survival rates (cancer)								
Colon	0.649	0.648	0.616	0.637	0.641	0.63	0.649	0.633
relative US	1	0.998	0.949	0.982	0.988	0.971	1	0.975
Cervical	0.626	0.652	0.695	0.650	0.668	0.675	0.683	0.645
relative US	1	1.042	1.110	1.038	1.067	1.078	1.091	1.030
Breast	0.902	0.860	0.861	0.867	0.860	0.866	0.888	0.854
relative US	1	0.953	0.955	0.961	0.953	0.960	0.984	0.947
Leukemia	0.895	0.911	0.940	0.886	0.878	0.904	0.890	0.847
relative US	1	1.018	1.050	0.990	0.981	1.010	0.994	0.946

Table 1: **Price and Efficiency Differences Across Countries:** Price information (2013 dollars) for angiogram, scan and bypass surgery from International Federation of Health Plans ([IFHP \(2013\)](#)) while the drug price index is taken from [Danzon \(2018\)](#). Fee information for physicians from [Laugesen and Glied \(2011\)](#) in 2008 dollars. Hospital spending per discharge for 2009 from OECD Health Data in 2011 dollars. Five-year cancer survival rates (2010-2014) from OECD Health Data

	Country							
	<i>DE</i>	<i>DK</i>	<i>FR</i>	<i>IT</i>	<i>NL</i>	<i>SE</i>	<i>SP</i>	<i>US</i>
$\rho_e$	0.9436	0.9182	0.9588	0.9433	0.9697	0.9182	0.9798	0.959
$\sigma_e^2$	0.0285	0.0150	0.0191	0.0303	0.0108	0.0150	0.0111	0.0396
$\sigma_u^2$	0.0967	0.0751	0.1143	0.0806	0.1192	0.0751	0.1364	0.1257
$\frac{\sigma_e^2}{1-\rho_e^2}$	0.26	0.0956	0.2367	0.275	0.181	0.0956	0.2776	0.493

Table 2: **Covariance Structure of Income Process:** Parameter estimates by minimum distance as outlined in text.  $\rho_e$  refers to the persistence of permanent shocks,  $\sigma_e^2$  the variance of permanent shocks and  $\sigma_u^2$  the variance of transitory shocks (assumed measurement error in model and set to zero).

	Country							
	<i>DE</i>	<i>DK</i>	<i>FR</i>	<i>IT</i>	<i>NL</i>	<i>SE</i>	<i>SP</i>	<i>US</i>
$\mu$	0.127	0.149	0.088	0.237	0.097	0.162	0.228	0.136
$\alpha$	0.372	0.360	0.379	0.470	0.393	0.461	0.373	0.384
$\delta$	0.039	0.043	0.04	0.039	0.041	0.046	0.037	0.048

Table 3: **Calibration of Auxiliary Parameters:**  $\mu$  refers to the co-insurance rate of health insurance,  $\alpha$  refers to the expenditure share of capital while  $\delta$  refers to the depreciation rate on capital. Refer to text for sources for these data.

$\sigma$	$\phi$	$\alpha_0$
2.113	0.834	0.145
(0.035)	(0.034)	(0.030)

Table 4: **Common Parameters:** Estimates by method of simulated moments on U.S. data. standard errors in parenthesis.

	US	DE	DK	FR	IT	NL	SE	SP
$\alpha_{10}$	-0.533	-0.813	-1.180	-0.851	-0.215	-0.970	-0.877	0.131
	(0.015)	(0.027)	(0.067)	(0.066)	(0.004)	(0.382)	(0.048)	(0.005)
$\alpha_{11}$	3.727	4.180	4.634	4.432	3.974	4.486	4.644	3.915
	(0.033)	(0.040)	(0.075)	(0.066)	(0.019)	(0.066)	(0.067)	(0.044)
$\frac{p}{p_{US}}$	1	0.770	0.965	0.835	0.641	0.772	0.958	1.022
	-	(0.006)	(0.069)	(0.010)	(0.022)	(0.058)	(0.006)	(0.026)
$\frac{A}{A_{US}}$	1	1.021	1.289	0.939	0.710	0.999	0.870	0.877
	-	(0.006)	(0.052)	(0.009)	(0.012)	(0.020)	(0.085)	(0.128)

Table 5: **Country-Specific Parameters:** Estimated by method of simulated moments. Standard errors in parenthesis.

	GDP share of health expenditures $s$			Fraction good health $p(h = 1)$			Income-Health gradient $\bar{p}_4$		
	U.S.	Europe	$\Delta$	U.S.	Europe	$\Delta$	U.S.	Europe	$\Delta$
baseline	0.154	0.090	0.064	0.9	0.959	-0.059	1.273	1.061	0.212
price	0.141	0.09	0.051	0.92	0.962	-0.042	1.212	1.062	0.15
efficiency	0.157	0.094	0.063	0.894	0.958	-0.064	1.288	1.055	0.233
health risks	0.1	0.098	0.002	0.918	0.93	-0.012	1.221	1.149	0.071

Table 6: **Decomposition of the Differences between U.S. and Europe:**  $s$  is the GDP share of health expenditures,  $p(h = 1)$  is the fraction of individuals in good health and  $\bar{p}_4$  is the relative probability to be in good health within fourth income quartile (Income-health gradient). For each scenario,  $\Delta$  measures the percentage difference between the U.S. and the average over the countries in the E.U.

		$e_0$	$e_4$	$e_9$	Aggregate
GE	Bad health	101.07	101.61	101.39	101
	Good health	101.01	101.02	100.85	
PE	Bad health	100.1	101.02	100.83	100.38
	Good health	100.1	100.41	100.35	

Table 7: **Lifetime Cost-of-living in the U.S. Induced by Wedges:** We compute the lifetime cost-of-living index (multiplied by 100) in the U.S. for a change in health service wedge ( $p$ ) to European levels. We report indices in partial equilibrium (PE) and accounting for general equilibrium effects (GE) for individuals in bad and good health as well as for three levels of income (lowest  $e_0$ , middle  $e_4$ , and  $e_9$  highest).